

### REMARKS

Claims 1, 2, 4, and 6 to 16, as amended, appear in this application for the Examiner's review and consideration. Claims 13 to 16 have been withdrawn from consideration, as being drawn to non-elected subject matter. Claims 1, 2, 4, and 6-12 are currently rejected. Claim 1 has been amended, support for the amendment can be found in the specification on page 1, lines 9-20. Claim 11 has been amended, support for the amendment can be found in the specification on page 2, lines 20-22 and page 2, line 33 to page 3, line 1.

#### **1. Rejection of Claim 11 Under 35 U.S.C §112 First Paragraph**

The Examiner has rejected claim 11 under 35 U.S.C. §112, first paragraph, as allegedly lacking enablement. According to the Examiner, the specification, while enabling for increased thermal conductivity of 50% for a 10% volume loading of silicon carbide, does not reasonably provide enablement for at least 5% increase compared to that of a fuel arrangement from pure uranium dioxide. In particular, according to the Examiner the specification does not reasonably provide enablement for at least 5% increase, i.e. unlimited increase of thermal conductivity.

In Applicant's previous response, Applicant submitted that the specification describes that the treatment process of incorporating a precursor liquid in the uranium oxide nuclear fuel increases the thermal conductivity of the uranium dioxide fuel. In addition, the thermal treating process is repeated, when desired, to allow more incorporation of precursor liquid, as taught in the specification on page 5, second paragraph. The specification also describes on page 6, as the Examiner noted, that thermal conductivity of uranium dioxide fuel is increased by the presently claimed treatment, for example by 50% for a 10% volume loading of silicon carbide, thus at least 5%. Moreover, the skilled artisan would not consider an increase of the thermal conductivity lower than 5% as significant. Such increase is in the range of the industrial variability between lots of "conventional uranium dioxide" and too low to allow considerable effect on the in-reactor behavior of the nuclear fuel. Thus, the skilled artisan will first define the desired increase in the thermal conductivity (for example by 50%), which is higher than 5% (i.e. the standard variability of the parameter) and then perform, and if needed repeat, the thermal treatment until obtaining the desired thermal conductivity. To determine whether an increase of at least 5% in thermal conductivity has

been achieved by the claimed process requires only routine experimentation of the conductivity of the obtained uranium dioxide fuel.

Thus, Applicant submits that the term "until a thermal conductivity of the fuel arrangement is increased at least 5% compared to that of a fuel arrangement" as described in the specification is not a term that quantifies the required increase in thermal conductivity of the fuel arrangement but describes a minimum amount of repeating cycles required in the claimed process. A person of ordinary skill in the art would understand from the specification that in the claimed process the thermal treatment cycle may need to be repeated and that the amount of repeating cycles is dictated by whether the thermal conductivity has increased to the desired level (at least a 5% increase) or not.

Therefore, the skilled artisan would know how to make use of the claimed invention by thermally treating the uranium oxide fuel, infiltrated with a precursor liquid, as clearly described in the specification, to obtain an uranium oxide fuel with the desired increase (of at least 5%) in thermal conductivity, as in claim 11, by repeating, if required, the claimed thermal treating process. Accordingly, claim 11 is enabled by the specification and withdrawal of the rejection of claim 11 under 35 U.S.C. §112, first paragraph is respectfully requested.

## **2. Rejection of Claim 11 Under 35 U.S.C §112 Second Paragraph**

Claim 11 is rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter. According to the Examiner the meaning of the term "pure uranium dioxide" is unclear and is unclear from the specification that the term "pure uranium dioxide" means "unmodified uranium dioxide."

In response, applicants have amended in claim 11 the term "pure uranium dioxide" to "conventional uranium dioxide." Further, Applicant submits that the specification describes that the claimed process provides increased thermal conductivity compared to conventional nuclear fuel. Conventional nuclear fuel is further characterized as uranium dioxide in unmodified form as described on page 1, lines 24 to 27. For this reason, Applicant submits that the term "conventional uranium dioxide" would be understood by the skilled artisan reading the specification as conventional uranium dioxide which is in unmodified form and is therefore supported by the specification. Accordingly, withdrawal of the rejection of claim 11 for being indefinite under 35 U.S.C. §112, second paragraph, is respectfully requested.

**3. Rejection of Claims 1, 3-9, and 11-12 under 35 U.S.C. §103(a)**

Claims 1, 3-9, and 11-12, were rejected under 35 U.S.C. §103(a) as allegedly being obvious over GB1035789 in view of Carley-Macauley et al (US 3164487). According to the Examiner, GB '789 discloses a method of producing a nuclear fuel body, uranium carbide, with very low permeability to gases comprising impregnating a porous body comprising nuclear fuel element with a polymerizable substance such as furfuryl alcohol, by immersing nuclear fuel body in a bath of the polymerizable substance, curing, and carbonizing the cured substance. Further, the Examiner asserts that Carley-Macauley et al disclose that uranium oxide or uranium carbide can be used as a nuclear fuel. In response to Applicant's previous arguments that in GB '789 it is the porous graphite matrix containing protectively coated nuclear fuel particles and not, as is claimed, the porous nuclear fuel that is impregnated with a polymerizable substance, the Examiner asserts that claim 1 recites a porous uranium dioxide arrangement not uranium dioxide itself and in the absence of a definition "a porous uranium dioxide arrangement" was given its broadest reasonable interpretation.

In response, Applicant submits that independent claim 1 relates to a method of preparing an uranium dioxide fuel in pellet form for use in a light water reactor, comprising: providing a porous uranium dioxide arrangement; infiltrating the porous uranium dioxide arrangement with a precursor liquid; and curing and thermally firing the porous uranium dioxide arrangement with the infiltrated precursor liquid such that the precursor liquid is converted to a second phase. Thus, the claimed invention, as amended in independent claim 1, is directed to an uranium oxide nuclear fuel in pellet form for use in a light water reactor as clearly supported by the specification on page 1, lines 10-20. Such nuclear fuel uranium dioxide pellet is inserted in a zirconium alloy cladding (page 1 line 30 - page 2 line 2). This nuclear fuel body for use in a light water reactor is significantly different from the nuclear fuel bodies for use in a High Temperature Graphite Reactor (HTGR) as disclosed in the cited references. Moreover, the graphite based nuclear fuel material disclosed in the cited references cannot be used in the light water reactor as claimed. For this reason alone the method of preparing a nuclear fuel as in the claimed invention is clearly distinct from and not taught or suggested by the cited references.

Further, with respect to the Examiners assertions regarding the term porous uranium dioxide arrangement, one skilled in the art would immediately understand from reading the specification that the term refers to a uranium dioxide matrix that is porous. On page 3, lines 16 to 27, of the specification the uranium dioxide arrangement is described as an uranium

dioxide matrix. For example in lines 16 and 17 the liquid precursor liquid (impregnant) is penetrating a uranium dioxide matrix and in lines 24-27 "incorporation of the precursor liquid into all of the pores in the uranium dioxide matrix" is described. Moreover, the result of the claimed process is the incorporation of silicon carbide into the matrix of uranium dioxide as disclosed on page 4, lines 14-15 of the specification. For these reasons, applicant submits that the Examiner's interpretation of the term uranium dioxide arrangement in claim 1 is inconsistent with the disclosure in the specification with respect to a uranium dioxide arrangement and the use of the term uranium dioxide matrix therein. Accordingly, Applicant submits that the claimed invention is distinct and non-obvious for the reasons in Applicant's previous response.

In addition, GB '789 is directed to a method of preparing a solid fuel body, by impregnating pores of the fuel body with a polymerizable substance, and subsequently curing, carbonizing and partially graphitizing the substance to reduce the gas permeability of the fuel body. The fuel body in the GB '789 patent, which is a high temperature reactor fuel, comprises a graphite matrix and dispersed therein nuclear fuel particles, each of which is encased in a protective pyrolytic carbon coating. The nuclear fuel particles are necessarily carbides of nuclear fission material considering that GB '789 discloses that if the nuclear fission material is an oxide such material is first converted to a carbide. See GB '789 page 2 lines 85-90 and 116-122. The protective carbon coating on the nuclear fuel material also serves to protect against exposure of the nuclear fuel material to for example the curing and carbonizing of the polymerizable substances that are employed in the disclosed method to prepare a nuclear fuel element. See GB '789 page 2, lines 65-72. Accordingly, in addition to Applicant's previous argument that in contrast to a porous nuclear fuel which is being impregnated with a polymerizable substance it is the porous graphite matrix which contains protectively coated nuclear fuel particles that is being impregnated with a polymerizable substance in the method disclosed in GB'789, the nuclear fuel material in disclosed GB '789 is protected against impregnation with a polymerizable substance and specifically excludes uranium dioxide.

Carley-Macauley et al disclose a method of pyrolytically carbonizing a carbon based nuclear fuel body, which comprises particles of a metal oxide or carbide, by impregnating the nuclear fuel body with a gas, not a liquid precursor. Although the disclosure in Carley-Macauley et al describes that both metal oxides and carbides may be used it is highly recommended that metal carbides are used as nuclear fuel particles. The gasses used in the

process are chosen such that polymerization is less likely as disclosed in column 4, lines 30 to 38. These impregnated gasses are carbonized in the process of Carley-Macauley et al, again not disclosing a curing of the impregnant.

Therefore, Applicant respectfully submits that GB '789 fails to teach or suggest the use a porous uranium oxide nuclear fuel and infiltrating it with a liquid precursor, which is subsequently thermally treated by first curing and then firing the uranium dioxide arrangement, as in the presently claimed invention. In fact, GB '789 teaches away from using porous uranium dioxide as it teaches the use of metal carbides as nuclear fuel particles. Further, GB '789 fails to teach that a porous uranium dioxide arrangement is impregnated with a polymerizable substance as the nuclear fuel particles are protectively coated to protect against the curing and carbonizing of such polymerizable impregnant, effectively teaching away from the claimed method. This failure in the disclosure of GB '789 is not cured by the disclosure of Carley-Macauley et al teaching a method of pyrolytically carbonizing a nuclear fuel body, wherein the nuclear fuel particles are preferably metal carbides and more preferably are carbon coated nuclear fuel particles embedded in a matrix. Moreover, as discussed in Applicant's previous arguments Carley-Maceuley et al teach the use of suitable gasses in their method of pyrolytically carbonizing a nuclear fuel body which are less likely to polymerize, thereby effectively teaching away from the curing step required in the presently claimed invention. Thus, Carley-Macauley et al also do not cure the failure in GB '789 to teach or suggest to impregnate a porous uranium dioxide arrangement with a polymerizable substance, curing the substance and then thermally firing the substance. For these reasons, GB'789 and Carley-Macauley teach away from the claimed invention and even when combined the GB'789 patent in combination with Carley-Macauley et al does not teach or suggest a method of providing a porous uranium dioxide, infiltrating the uranium dioxide with a polymerizable liquid precursor and curing and firing the infiltrated uranium dioxide to obtain uranium dioxide with a second phase as presently claimed.

Therefore, Applicant submits that the Examiner has failed to state a prima facie case of obviousness and thus claim 1, and claims 4, 6-9, and 11-12, dependent thereon, are non-obvious over GB '789 in view of Carley-Macauley et al, and withdrawal of the rejection is respectfully requested.

**4. Rejection of Claims 1, 3-9, 11-12 under 35 U.S.C. §103(a).**

Claims 1, 3-9, and 11-12, were rejected under 35 U.S.C. §103(a) as allegedly being obvious over Carley-Macauley et al in view of Nicholson et al (US 3,035,325) and Mysels (US 4,073,834). According to the Examiner, Carley-Macauley et al disclose a method of producing carbon-impregnated nuclear fuel with very low permeability to gases by pyrolysis of methane and other hydrocarbons. The Examiner further asserts that although Carley-Macauley et al fail to teach an impregnation with a liquid precursor Nicholson et al disclose impregnation of a porous body with a resinous solution or furfural followed by carbonization. According to the Examiner, Nicholson teaches an impregnating technique for depositing carbon in the pores of substantially any refractory body having an intercommunicating network. Moreover, according to the Examiner, Mysels teaches that carbon can be deposited in the pores in a fuel arrangement by first curing a prepolymer and then decomposing the cured polymer and carbonizing the material at 1200°C or higher. In response to Applicant's previous arguments that there is no motivation to combine the cited references the Examiner asserts that the reason or motivation to modify the reference may often suggest what the inventor has done but for a different purpose to solve a different problem. According to the Examiner it is not necessary that the cited references suggest the combination to achieve the same advantage or result discovered by applicant.

Applicant submits that the Examiner has failed to support a prima facie obviousness determination as there is no motivation to combine the cited references despite the statements made in the final Office Action of June 21, 2007 in response to applicants previous arguments. Further, the cited references if combined fail to teach or suggest the claimed method.

The primary reference Carley-Macauley et al teaches away from impregnating a nuclear fuel body with a polymerizable substance because suitable gasses for penetrating the nuclear fuel body are selected specifically to minimize the risk of polymerization, whereas the secondary reference Mysels teaches the impregnating a nuclear fuel chamber in a nuclear fuel body with a polymerizable precursor liquid. Nicholson the other secondary reference, is not directed to preparing a nuclear fuel body but to preparing silicon impregnated silicon carbide bodies which are not suitable for use as a nuclear fuel body. The silicon nitride with which the silicon carbide bodies are impregnated with is characterized as a solid as opposed to a gas as in Carley-Macauley et al or Mysels.

Moreover, none of the cited references teaches or suggest impregnating a porous uranium dioxide as in the claimed process because the porous artifact in Carley-Macauley et al is carbon based, in Nicholson it is a silicon carbide body, and in Mysels it is a graphite block with fuel chambers filled with carbon coated nuclear fuel and "shim" graphite. In addition, the two references regarding nuclear fuel bodies (Carley-Macauley et al and Mysels) teach or suggest the use of carbon coated nuclear fuel (metal carbide, although metal oxides are mentioned in Carley-Macauley et al it is disclosed therein that they are preferably converted to the metal carbide for use in the nuclear fuel body) and thus not porous uranium oxide which can be impregnated with a polymerizable substance.

As described above, Applicant submits that independent claim 1, as amended, relates to a method of preparing an uranium dioxide fuel in pellet form for use in a light water reactor, comprising: providing a porous uranium dioxide arrangement; infiltrating the porous uranium dioxide arrangement with a precursor liquid; and curing and thermally firing the porous uranium dioxide arrangement with the infiltrated precursor liquid such that the precursor liquid is converted to a second phase. Thus, the claimed invention, as amended in independent claim 1, is directed to an uranium oxide nuclear fuel in pellet form for use in a light water reactor which is significantly different from the nuclear fuel bodies for use in a High Temperature Graphite Reactor (HTGR) as disclosed in the cited references, see for example Carley-Macauley et al and Mysels. For this reason alone the method of preparing a nuclear fuel as in the claimed invention is clearly distinct from and not taught or suggested by the cited references.

In addition, infiltrating the porous uranium dioxide arrangement involves infiltration of a porous uranium dioxide matrix as described in the specification. Carley-Macauley et al discloses a method of pyrolytically carbonizing a nuclear fuel body by impregnating the nuclear fuel body with a gas, not a liquid precursor. The gasses used in the process are chosen such that polymerization is less likely as disclosed in column 4, lines 30 to 38. These impregnated gasses are carbonized in the process of Carley-Macauley et al, again not disclosing a curing of the impregnant. Accordingly, Carley-Macauley fails to teach infiltrating a liquid precursor material which is thermally treated by curing and then firing to a form a second phase in an uranium dioxide nuclear fuel arrangement.

Further, Nicholson et al discloses methods of making silicon carbide bodies from silicon nitride, a solid. The silicon carbide bodies are prepared by rapidly heating silicon nitride to above 1900°C in the presence of a carbide. The silicon nitride with which the

silicon carbide bodies are infiltrated is a solid and not a polymerizable precursor liquid. The silicon carbide bodies prepared by the method disclosed in Nichols et al are not nuclear fuel bodies, let alone porous uranium dioxide nuclear fuel. Mysels discloses a method of preparing a nuclear fuel element by impregnating a porous graphite block containing nuclear fuel chambers with a carbonizable impregnant which penetrates the fuel chambers. The fuel chambers contain nuclear fuel material which is coated with (dense) pyrocarbon. The impregnant in the fuel chambers is then cured and carbonized to provide a carbon residue which binds the nuclear fuel material to the graphite block/body, preparing a high temperature reactor fuel.

For these reasons, there is no motivation to combine the teachings of Carley-Macauley et al with Nicholson et al and Mysels, the method of Nicholson et al directed to processes of preparing silicon carbide bodies and Carley-Macauley et al and Mysels directed to preparing nuclear fuel bodies. Further, even in combination Carley-Macauley et al in view of Nicholson et al and Mysels do not teach or suggest for the reasons stated above, the claimed method of infiltrating a porous uranium dioxide nuclear fuel material with a liquid precursor material and thermally treating the infiltrated uranium dioxide to obtain a second phase in the uranium dioxide by first curing and then firing the uranium dioxide arrangement as in independent claim 1. Accordingly, withdrawal of the rejection of claim 1, and claims 4, 6-9, and 11-12 dependent thereon, as obvious under 35 U.S.C. 103(a) over Carley-Macauley et al in view of Nicholson et al and Mysels is respectfully requested.

**5. Rejection of Claims 2 and 10 under 35 U.S.C. §103(a).**

Claims 2 and 10, were rejected under 35 U.S.C. §103(a) as allegedly being obvious over GB1035789 in view of Carley-Macauley et al/Carley-Macauley et al in view of Nicholson et al and Mysels/, and further in view of Burnham et al (US 3,129,141) and Chayka (US 5,952,046). The Examiner refers to the assertions made with respect to claims 1, 3-9, and 11-12 over the cited references and asserts that Burnham et al teaches that silicon carbide may be used for making a dense body of a nuclear fuel element. Moreover, although the cited references fail to teach that silicon carbide is impregnated from a polymerizable allylhydridopolycabosilane (AHPCS), according to the Examiner Chayka teaches that liquid AHPCS is a commercially known silicon carbide source. In response to Applicant's previous arguments the Examiner further asserts that because the teaching in Burnham et al one of skill in the art would have used a silicon carbide instead or in addition to graphite in the cited



prior art with the expectation of providing the desired dense body and therefore there is clear motivation to combine the cited references with Burnham et al. the teaching it is desirable that a nuclear fuel element comprises a dense body

As described above, Applicant submits GB '789 in view of Carley-Macauley et al does not teach or suggest, nor is there motivation to combine Carley-Macauley et al with Nicholson et al and Mysels to teach or suggest the method of independent claim 1, of preparing a nuclear fuel in pellet form for use in a light water reactor by infiltrating porous uranium dioxide with a liquid precursor material and thermally treating the infiltrated uranium dioxide to obtain a second phase by first curing and then firing the infiltrated uranium dioxide. These references, alone or in combination, teach methods of carbonizing porous nuclear fuel bodies/elements for use in a high temperature graphite reactor (HTGR) by impregnating such porous nuclear fuel body with a precursor material that is carbonized to obtain a high temperature reactor fuel, but fail to disclose infiltrating porous uranium dioxide nuclear fuel with a liquid precursor material and curing the liquid precursor infiltrate within the uranium dioxide arrangement to prepare the claimed nuclear fuel uranium dioxide.

Burnham et al is directed to a method of preparing a nuclear fuel element comprising a dense body of uranium carbide, graphite, silicon carbide and silicon. Thus, Burnham et al also disclose a nuclear fuel for use in a High Temperature Graphite Reactor based on graphite, which nuclear fuel cannot be used in a light water reactor as the claimed invention. Further, the uranium carbide is in the form of carbon coated uranium particles which cannot be infiltrated, instead of a porous uranium dioxide matrix which is infiltrated with a polymerizable precursor liquid. Further, in the method of Burnham et al, the above recited particles are mixed, either alone or preferably with silicon carbide, with suitable resin binder, then pressed in a shape and the resin is cured. This material is then immersed in molten silicon during which the resin carbonizes and reacts with the silicon to form silicon carbide. The material obtained by the process of Burnham et al therefore is a silicon carbide as base material and incorporated therein the nuclear fuel material as described in column 1, lines 23-29. Therefore, Burnham et al does not teach or suggest infiltrating porous uranium dioxide with a liquid precursor material. Chayka is directed to the chemical vapor deposition of silicon carbide or carbide on substrates, and does not teach infiltrating and curing a liquid precursor in a nuclear fuel body or material.

For the reasons stated above, Applicant submits that GB'789 in view of Carley-Macauley and Carley-Macauley in view of Nicholson et al and Mysels fail to teach

infiltrating a porous uranium dioxide fuel material with a liquid precursor to obtain an uranium dioxide arrangement containing a second phase silicon carbide. The disclosure of Burnham et al and Chayka do not cure this failure. In fact, Burnham et al disclose using uranium carbide nuclear fuel which is protectively coated with graphite/carbide, effectively teaching away from infiltrating a porous uranium dioxide nuclear fuel with a precursor liquid as in presently independent claim 1, from which claims 2 and 10 depend. Moreover, the disclosure in Burnham et al teaches impregnating a porous nuclear fuel body, not a nuclear fuel uranium dioxide arrangement. Accordingly, the cited references further in view of Burnham et al, even if combined, fail to suggest the presently claimed method. Further, Chayka, directed to a method of chemical vapor deposition, also fails to teach a method of infiltrating and curing a liquid precursor into an uranium dioxide arrangement.

Thus, the cited references fail to teach or suggest the presently claimed method as in independent claim 1, as amended, let alone the methods of claims 2 and 10, which depend thereon, claim 2 relating to the method of claim 1, wherein the liquid precursor material is defined as AHCP, claim 10 which relates to the method of claim 1, wherein the second phase is solid silicon carbide. Accordingly, withdrawal of the rejection of claims 2 and 10 under 35 U.S.C. 103(a) as obvious in view of the cited references is respectfully requested.

**6. Rejection of Claim 11 under 35 U.S.C. §103(a).**

Claim 11, was rejected under 35 U.S.C. §103(a) as allegedly being obvious over Carley-Macauley et al in view of Nicholson et al and Mysels, and further in view of GB '789. The Examiner refers to the assertions made with respect to claims 1, 3-9, 11-12 over Carley-Macauley et al in view of Nicholson et al and Mysels and asserts that GB '789 discloses that the desired low gas permeability is achieved by repeating the steps of impregnating, curing and carbonizing.

According to substantially the same reasoning as applied above submitting that claims 1, 3-9 and 11-12 are non-obvious over Carley-Macauley et al in view of Nicholson et al and Mysels et al, Applicant submits that claim 11 is non-obvious over these reference in further view of GB'789. The cited references fail to teach or suggest, either alone or in combination the claimed method as in independent claim 1 from which claim 11 depends. In fact, as described above there is no motivation to combine the cited references and Mysels et al effectively teaches away from infiltrating porous uranium dioxide. This failure in the

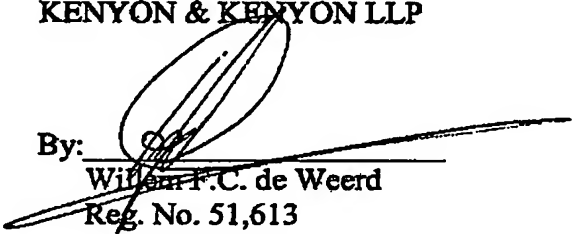
disclosures of Carley-Macauley et al, Nicholson et al and Mysels, even when they are combined, is not cured by the disclosure of the GB'789 patent as described above when discussing the GB'789 patent in view of claim 1, 3-9, and 11-12. Specifically, none of the cited references teach or suggest the claimed uranium dioxide nuclear fuel in pellet form for use in a light water reactor but preparing a solid nuclear fuel based in graphite for use in a High Thermal Graphite Reactor, which is significantly different from the nuclear fuel prepared by the claimed process. And although the GB'789 patent teaches to repeat a process of impregnating, curing and carbonizing a porous nuclear fuel body, having dispersed within its matrix nuclear fuel material, with a polymerizable substance until a desired level of gas impermeability, it does not teach or suggest in combination with the other references cited the method of claim 11. GB'789 as discussed above is directed to impregnating a porous nuclear fuel body comprising protectively coated nuclear fuel particles with a polymerizable substance, which is then carbonized. Again, the GB'789 patent teaches the use of protectively coated nuclear fuel particles, effectively teaching away from the use of porous uranium dioxide as presently claimed. Therefore, withdrawal of the rejection of claim 11 under 35 U.S.C. 103(a) as obvious in over Carley-Macauley et al in view of Nicholson et al and Mysels in further view of GB'789 is respectfully requested.

**7. Conclusion**

Applicant thus submits that the entire application is now in condition for allowance, an early notice of which would be appreciated. Should the Examiner not agree with Applicant's position, a personal or telephonic interview is respectfully requested to discuss any remaining issues prior to the issuance of a further Office Action, and to expedite the allowance of the application.

Respectfully submitted,  
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